A case Series Describing Thermal Injury Resulting From Zeolite Use for Hemorrhage Control in Combat Operations

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ABSTRACT

Four cases are presented to illustrate cutaneous burns sustained with the use of zeolite in the treatment of major hemorrhage secondary to combat wounds. Zeolite, a microporous crystalline aluminosilicate granular hemostatic agent, can cause secondary thermal injuries through an exothermic reaction that is likely related to the absorption of free fluid at the hemorrhage site. Understanding of this process may help both military and civilian EMS personnel avoid or minimize secondary thermal injury while still benefiting from zeolite's hemostatic capabilities. **Key words:** burn, hemorrhage, QuikClot®, trauma, zeolite

PREHOSPITAL EMERGENCY CARE 2007;11:67–71

Introduction

Almost 50% of current combat fatalities in Iraq and Afghanistan before evacuation and up to 80% of civilian trauma fatalities within the United States are attributed to uncontrolled hemorrhage.[1,2] Data from the Vietnam conflict also suggested that exsanguinations from extremity wounds accounted for more than half of the potentially preventable deaths in that conflict.[3] It is hypothesized that some of these deaths may have been prevented by the prompt application of a tourniquet, a lesson that has been acted on in the current conflicts in Afghanistan and Iraq. However, there are many anatomical regions where tourniquets cannot be used or may be ineffective, and which necessitate an alternative method to achieve hemostasis. The vision of a Ranger dying from uncontrolled hemorrhage from a groin injury in Somalia, so vividly portrayed in the movie *Black Hawk Down*, serves as such an example. Thus, hemostasis research and the development of an effective method for treatment of uncontrolled hemorrhage has become a major priority in combat casualty care research programs.

Two of the most common newer hemostatic agents, zeolite powder (QuikClot®, Z-Medica, Wallingford, CT) and the chitosan dressing (HemCon®, HemCon Inc, Portland, OR) have been recently reviewed in the literature and are being used in current combat operations with some success.[4–6] The use of these agents is not limited to combat operations. In fact, there is growing interest in the use of these products in the civilian prehospital setting, emergency departments, and operating rooms throughout North America.[7] However, previous studies have raised concern about possible thermal injury to surrounding viable tissue due to an exothermic reaction created with zeolite use.[8,9] This case series is the first human description of thermal injury associated with zeolite use for hemorrhage control in current combat operations.

Case 1

A 20-year-old male, who was riding in a vehicle convoy, sustained shoulder wounds secondary to an improvised explosion device (IED). The patient was wearing a standard issue desert camouflage uniform and an improved body armor (IBA) protective vest. He reported immediate shoulder pain and bleeding from his wounds. Within minutes of the injury, the patient was treated at the scene by a Navy corpsman (medic) who initially applied a gauze bandage. The patient and corpsman reported that the bleeding was "a lot," and zeolite was applied to the wound. The patient sustained no other injuries from the IED and was transported to the Forward Support Medical Company (FSMC) for evaluation and further treatment.

Primary and secondary survey at the FSMC demonstrated a 2 cm by 2 cm puncture wound to his right shoulder and a 1 cm by 1.5 cm puncture wound to his right supramidcalvicular area. There was a 5 cm by 8 cm area of partial thickness burn between the wounds (approximately 1% total body surface area [TBSA]). (Figure 1). The remainder of the patient's physical exam was unremarkable.

Local wound care was performed to include saline irrigation, debridement of the friable tissue, and

Received June 30, 2006, from the US Army Institute of surgical Research, Fort Sam Houston, Texas, (JM, AP) 121 General Hospital, Seoul, Korea, (TH), and Naval Medical Center, Portsmouth, Virginia (KJK). Revision received September 7, 2006; accepted for publication September 10, 2006.

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doi: 10.1080/10903120601021176

Report Documentation Page

Form Approved
OMB No. 0704-0188

1. REPORT DATE	2. REPORT TYPE	3. DATES COVERED
JUN 2006		**00-00-2006 to 00-00-2006**

4. TITLE AND SUBTITLE	5a. CONTRACT NUMBER
A Case Series Describing Thermal Injury Resulting From Zeolite Use for Hemorrhage Control in Combat Operations	5b. GRANT NUMBER
	5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S)	5d. PROJECT NUMBER
	5e. TASK NUMBER
	5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) **U.S. Army Institute of Surgical Research (USAISR),3400 Rawley E. Chambers Avenue,Fort Sam Houston ,TX,78234-6315**	8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)	10. SPONSOR/MONITOR'S ACRONYM(S)
	11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution unlimited

13. SUPPLEMENTARY NOTES

14. ABSTRACT

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15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT	b. ABSTRACT	c. THIS PAGE			
unclassified	**unclassified**	**unclassified**	**Same as Report (SAR)**	**6**	

FIGURE 1. Right shoulder injury secondary to an IED with partial thickness burn.

deroofing of the blisters around the burn area. Small, granular particles of zeolite were still present in each wound despite aggressive and copious irrigation. They were adherent to the tissue requiring multiple passes with a sterile cotton swab to remove. After a period of observation and consultation with his primary physician who would be doing follow-up care, the patient was discharged to his unit to follow up the next day. Adequate analgesia was provided and the patient was empirically placed on prophylactic antibiotics.

The open fragmentation wounds began to heal within 3 days. Small, crusted eschars formed, and the patient reported minimal pain at these sites. The superficial partial thickness burn near his clavicle took approximately 3 weeks to heal. Because of the location, the patient was unable to wear his protective body armor without considerable pain and bleeding. After his burn healed, he was able to return to full duty without restrictions.

CASE 2

A 22-year-old male sustained a fragmentation wound to the first webspace and the hypothenar eminence of his left hand when unexploded ordinance detonated. He immediately wrapped his hand in a scarf and elevated it above his head. The patient was cared for by a medic in the field who noted "spurting blood" and applied zeolite to both wounds. The patient described a burning sensation when the zeolite was applied, and his hand felt like it was "on fire." No other injuries were identified in the field, and the patient was brought to the FSMC for additional evaluation.

Primary and secondary surveys at the FSMC revealed a 1.5 cm by 1.5 cm puncture wound to his hypothenar eminence and a 3 cm by 2 cm puncture wound to the dorsum of his first webspace with a normal neurovascular exam. Surrounding each puncture wound site was a partial thickness burn secondary to the zeolite. The remainder of the physical exam and radiographs of the hand were unremarkable.

Local wound care was performed to include saline irrigation and blister debridement. The patient was placed in a bulky dressing, splinted, and discharged to follow-up the next day. Adequate analgesia was provided, and the patient was empirically placed on prophylactic antibiotics. On serial exams over the next week, the patient reported continued pain over the burn sites. His open wounds were closed by delayed primary closer with good cosmesis. One month after the incident, the patient still complained of pain near the well-healed burn sites. He reported some difficulty grasping

items secondary to pain but was able to return to full duty without sequalae.

Case 3

An approximately 45-year-old male civilian sustained multiple fragmentation wounds to his lumbar region, posterior thighs, and buttocks secondary to an IED. He was found ambulatory at the scene complaining of severe pain in his buttocks and legs. The medic noted "lots of blood" near the superior aspect of his gluteal cleft. The patient was placed prone on a litter, and zeolite was applied to the wounds on his buttocks, gluteal cleft, and posterior thighs. No other injuries were identified in the field, and the patient was brought to the FSMC for evaluation.

Primary and secondary surveys showed multiple fragmentation wounds to the patient's buttocks, posterior thighs, and lower lumbar region. The largest wound was approximately 2 cm by 4 cm, located at the superior aspect of his right gluteal cleft and proximal thigh. This wound was surrounded by partial thickness burns that encompassed approximately 2% TBSA. There were also partial thickness burns to the inferior gluteal cleft, to the posterior perineum, and to the posterior thighs (approximately 1% TBSA). His abdominal exam was benign, and he had a normal focused abdominal sonogram for trauma (FAST). A digital rectal exam was unremarkable. He had a normal neurological exam and normal and equal pulses distal to the wounds. Lumbar spine, pelvis, and femur radiographs showed multiple metallic foreign bodies in the soft tissues of his lumbar region, buttocks, and posterior thighs without evidence of fractures or dislocations.

Adequate analgesia was provided, and the patient was given a dose of empiric prophylactic parenteral antibiotics. All of his wounds were copiously irrigated with normal saline. Because of the multiple penetrating wounds to his lumbar region and buttocks, the patient was transferred to the Combat Support Hospital for additional care. No additional follow-up was available.

Case 4

A 45-year-old Kurdish civilian male wounded by a blast from unexploded ordinance sustained a penetrating injury to the right thigh, resulting in copious bleeding at the scene. He was transported to a nearby surgical shock trauma platoon with a tourniquet in place, an intact distal pulse (even with the tourniquet on), and a zeolite dressing applied to the wound. He had stable vitals, no foreign body on x-ray, and the large soft tissue avulsion as his only injury. A thermal burn was noted surrounding the penetrating wound in his proximal, posterior right thigh (Figure 2), which was still covered with zeolite. The wound was explored, cleansed, and debrided under general anesthesia. After an overnight stay due to weather delay, the patient was transported

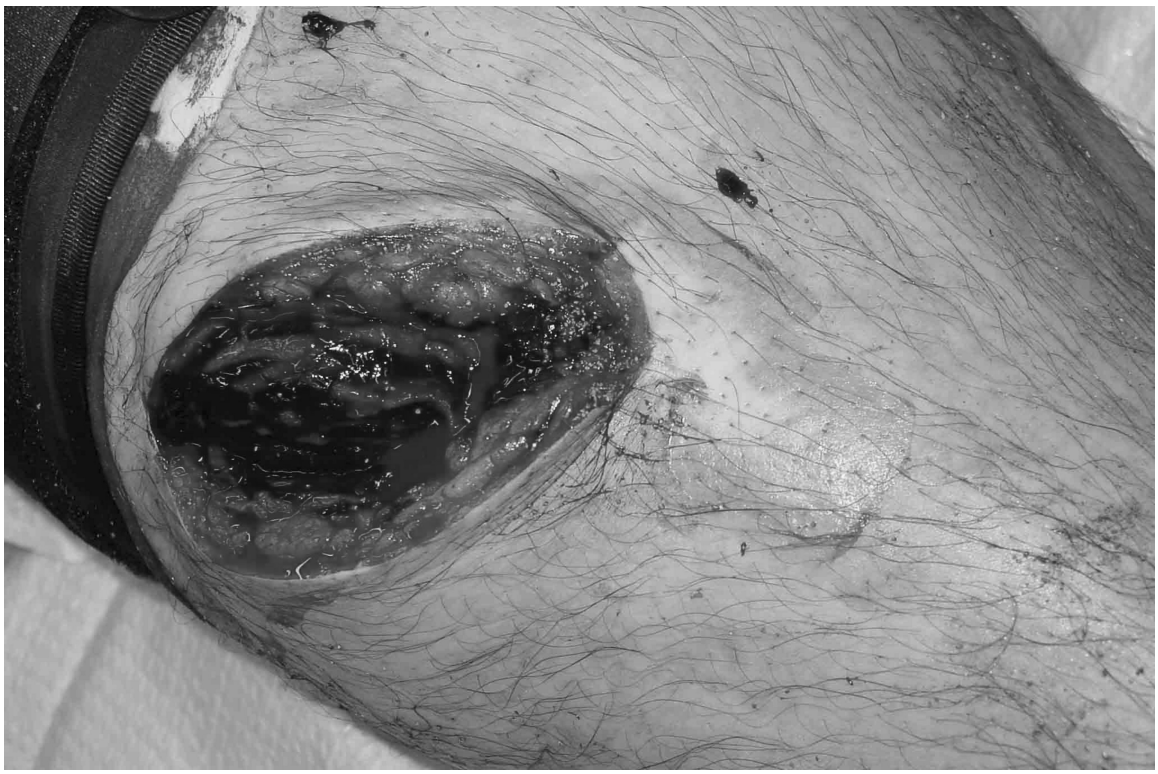

Figure 2. Thermal injury surrounding penetrating wound to the posterior proximal right thigh and gluteal cleft area.

to the Combat Support Hospital for further care. No additional follow-up was available.

DISCUSSION

QuikClot®, or zeolite, is a microporous crystalline aluminosilicate granular hemostatic agent, which is supplied in 3.5-ounce packages. It was approved by the FDA for external use on uncontrolled bleeding in 2002 and costs approximately $20 per packet. The zeolite granules are poured directly onto the site of bleeding, which results in a proposed mechanism of action of fluid adsorption resulting in accumulation and concentration of clotting factors and platelets. Although the exact composition of the granules is proprietary, the manufacturer advertises that the granules contain no biological substances, which eliminates the possibility of disease transmission or allergic reaction.

Zeolite has been shown to successfully control external hemorrhage in some animal studies, particularly femoral mixed arterial[10,11] and venous bleeding,[9] but was ineffective in another study.[12] There have also been over 60 case reports of successful zeolite use from U.S. Navy medical personnel currently deployed in Iraq and Afghanistan, with only anecdotal reporting of thermal injury.[3] In addition, there is one case study reporting successful use in a civilian coagulopathic patient with thoracoabdominal trauma.[7] Concern, however, has been raised over the exothermic process created with the zeolite granules during the adsorption of free fluid. Mild[10,11] to severe[8,9,12] exothermic reactions, with corresponding tissue damage, have been reported in animal studies. The data suggest that the exothermic reaction will be greater when more blood and more product is present at the site of application.[6] In cases where this is minimized (e.g., by tourniquet application), risk of thermal injury is lessened, but may still be present as seen in case 4. The QuikClot® manufacturer has worked closely with the U.S. Department of Defense to modify the product to reduce the exothermic process, but no data have been reported since modification. The present findings of thermal injury associated with the application of zeolite are consistent with observations in animal studies and reinforce the identified need for careful training of personnel prior to the use of the product.[13]

Although QuikClot® and the HemCon® bandage are the two hemostatic agents that are used in current combat operations for external hemorrhage control, the authors recognize that there are several other hemostatic agents available. Many of these agents and bandages are commercially available but have limited data to support their efficacy.[6] Because uncontrolled hemorrhage is also the leading cause of mortality in civilian trauma, some of these agents may be useful in the civilian emergency medical services (EMS) environment. Although most of the civilian trauma hemorrhage is due to liver and cardiac injuries, with almost one third involving a major vessel injury,[1] a retrospective review at two trauma centers reported 14 deaths from isolated hemorrhaging extremities.[14] Furthermore, with the increasing threat of possible terrorist attacks and bombings occurring domestically, civilian EMS agencies may need to respond to casualties with "combat-like" wounds that possess life-threatening, noncompressible external hemorrhage.

The ideal hemostatic agent for noncompressible external hemorrhage should be inexpensive, simple to apply, durable, possess minimal risk, require little training to use, be effective against severe bleeding that would otherwise lead to exsanguination, and be able to sustain hemostasis for at least several hours to permit safe evacuation of casualties to definitive care centers. Each of the agents used in current combat operations possesses its own advantages and disadvantages, and one may be more suitable than others for different levels of care depending on the environment and situation.[6]

SUMMARY

This case series describes secondary thermal injuries associated with the use of zeolite. Despite this potential complication, zeolite has shown to be a valuable hemostatic agent if used under the proper circumstances with appropriate provider education. Combat medics, prehospital EMS personnel, and other trauma care providers should be familiar with the indications and contraindications for its use to augment their hemorrhage control armamentarium and minimize the possibility of potential thermal injury.

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